# Department of Defense

# Small Arms Range Quality Assurance Project Plan(SAR-QAPP) Tool

**DoD Environmental Quality Workgroup**

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# Preface

The Small Arms Range (SAR) Quality Assurance Project Plan (QAPP) tool is a companion document to the Uniform Federal Policy for Quality Assurance Project Plans (UFP-QAPP) (Intergovernmental Data Quality Task Force (IDQTF) 2005).[1] It has been produced by the Department of Defense Environmental Data Quality Workgroup (DoD EDQW) to assist project managers and team members in planning for the investigation of closed SARs being managed under the Munitions Response Program at DoD installations and formerly used defense sites (FUDS). This tool provides information and examples to assist in completing five of the UFP-QAPP worksheets (10, 11, 17, 21, and 23) used to document the output of a systematic planning process for investigations at SARs. Used in conjunction with the UFP-QAPP and the remaining UFP-QAPP worksheets, it will help project teams generate a complete QAPP, i.e., a stand-alone document that addresses all elements of the national consensus standard ANSI/ASQ E-4, *Quality Systems for Environmental Data and Technology Programs,* for the collection and use of environmental data at Federal Facilities. Users of this tool must comply with existing DoD policy, Executive Orders, and federal and state laws and regulations.

Drawing upon the large amount of historical data, experience, and lessons learned from previous studies at SARs across all DoD Components, this tool identifies key considerations, provides examples, and summarizes attributes that are "typical" of SAR investigations in an effort to facilitate documentation of a systematic planning process (SPP). It can be used for investigations at closed, outdoor SARs at both recreational and combat training facilities that supported the firing of weapons discharging 50 caliber munitions or smaller (e.g., pistols, rifles, machine guns, and shotguns). It addresses short and long-distance ranges in addition to sporting clay, trap, and skeet ranges.

It is assumed that users of this tool already have a working knowledge of the SPP and the UFP-QAPP. The information and examples in this tool augment the SPP. It is emphasized that the final selection of sampling and analysis processes at any site should be tailored to site-specific conditions, future land use and intended uses of the data. The information and examples summarized in this tool, such as the contaminants of potential concern (COPCs), their transport pathways, and their respective bioavailabilities, are limited to SARs and range operations. Any additional COPCs that may exist based upon operations or activities within the site boundaries

[1] Both the original and optimized UFP-QAPP worksheets, as well as the UFP-QAPP manual, may be downloaded from the EPA Federal Facilities Library website at: http://www.epa.gov/fedfac/library.htm#quality

unrelated to SARs should be summarized in the conceptual site model and included in the SPP as necessary.

Examples of questions that project managers are faced with concerning SARs include the following:

- What contaminants of concern (COCs) are typically associated with specific types of small arms munitions and activities?
- What key aspects of range operation/activities are important for the conceptual site model (CSM)?
- What key questions or parameters should be identified during problem formulation?
- What are the typical transport and exposure pathways associated with specific COCs at SARs?
- What are the most appropriate sampling procedures and/or sample processing steps for the specific SAR investigation?
- What analytical methods should be used?
- What field screening procedures are available that could provide information relevant to project-specific data quality objectives (DQOs)?

Each worksheet in this tool includes green text, which provides specific instructions and considerations concerning the type of information needed for each element, and blue text, which provides examples of the types of information typically needed. It must be emphasized that the examples may not be applicable to every situation, and should not be construed to establish minimum requirements or standard practices. Examples of diagrams, maps and figures are included. The format, layout, and types of information provided in these examples should be considered as useful aids for inclusion in a SAR QAPP.

# Acronyms and Abbreviations

| Acronym | Definition |
|---|---|
| BTAG | biological technical assistance group |
| CERCLA | Comprehensive Environmental Response Compenstion and Liability Act |
| COPC | constituent of primary concern |
| CSM | conceptual site model |
| DoD EDQW | DoD Environmental Quality Work Group |
| DoD QSM | DoD Quality Systems Manual for Environmental Laboratories |
| DQO | data quality objective |
| DU | decision unit |
| FUDS | formerly used defense sites |
| GPS | global positioning system |
| IDQTF | Intergovernmental Data Quality Task Force |
| ISM | incremental sampling methodology |
| MPC | measurement performance criteria |
| NFA | no further action |
| O/RP | oxidation/reduction potential |
| PA/SI | preliminary assessment/site investigation |
| PAL | project action level |
| QAPP | quality assurance project plan |
| RI/FS | remedial investigation/feasibility study |
| RSL | residential screening level |
| SAR | small arms range |
| SOP | standard operating procedure |
| SPP | systematic planning process |
| TBD | to be determined |
| TOC | total organic carbon |
| TPP | technical project planning |
| UFP QAPP | Uniform Federal Policy for Quality Assurance Project Plans |
| UTL | upper threshold limit |
| XRF | X-ray fluorescense |

# QAPP Worksheet #10: Conceptual Site Model
# (UFP-QAPP Manual Section 2.5.2)
# (EPA 2106-G-05 Section 2.2.5)

This worksheet is used to summarize the project's conceptual site model (CSM) as it relates to the current investigation. For the purposes of this document, a CSM is a written and/or graphical representation of a SAR and surrounding areas that depicts what is known about the distribution of small arms munitions constituents and the physical, chemical, and biological processes that determine their transport and fate based on current and anticipated, future land-use scenarios. Relevant subject matter experts (e.g., risk assessors, chemists, hydrogeologists) should be consulted in development of the CSM. Note that the CSM does not need to describe every piece of information known about the site; rather, it should organize and summarize information in a concise manner that is relevant to the scope of the current investigation. The level of detail in the version of the CSM contained in the QAPP should be based on the types and significance of decisions to be made which will vary based on the phase and objectives of the investigation (e.g. risk assessment, nature and extent, etc.).

During the investigative phases of a project (e.g. PA/SI, RI/FS), the CSM is used as a tool to assist in the development of DQOs and to support professional judgments about sampling design. As the CSM evolves during later stages of a project, it is used to evaluate the feasibility of various remedial alternatives, including no further action (NFA), specific remedial activities, and institutional controls. At all stages of a project, the CSM is an important communication tool for regulators and stakeholders.

Examples of the types of information that may be important in developing a CSM for a SAR include the following:

**Physical setting and characteristics**

- Location
- Size
- Surrounding land use (current and anticipated future use)
- Vegetation
- Hydrogeology
- Topography
- Soil type(s)

- Surface water bodies and surface drainage patterns
- Groundwater and land use restrictions

**General, regional information**

- Climate
- Meteorological data
- Geological setting

**Range description**

- Type of range [e.g. pistol/rifle, shotgun, or machine gun.] For each type, identify typical arms, targets, ammunition, and constituents of concern.
- Locations, descriptions, and physical dimensions of former and existing structures, firing points, firing lanes, primary impact berms, side berms, safety fan/fallout areas, target launchers, shot fall zones, and targets. [For example, at shotgun ranges involving clay targets and fixed firing positions, lead shot are typically distributed in highest density in a fan between 375 and 600 feet from the firing positions and clay target fragments are found in highest density in a fan from 65 to 260 feet from the firing positions.]
- Estimated volume of munitions used, along with periods of use, if this information is available.
- Past operational and maintenance considerations.

**Constituents of Concern***: [Note: The following discussion is limited to constituents of potential concern (COPCs) contained in small arms munitions and clay targets. It does not address contamination resulting from activities unrelated to range operations.]*

- At small arms ranges, lead will be the primary COPC, due to its prevalence and relative toxicity (ITRC 2003); however in some instances, additional COPCs may exist, subject to the following considerations:
- At shotgun ranges (skeet, trap, and sporting clay ranges), antimony and arsenic may be COPCs in some circumstances. The lead alloy used in shotgun pellets is 96.4% lead, 3% antimony, and 0.6% arsenic (USAEC 2005).
- Based upon environmental conditions at the site and exposure point assumptions, PAHs may or may not be COPCs. While PAHs are contained in the clay targets used at shotgun ranges, studies have demonstrated that PAHs typically remain bound in the target fragments and do not leach to environmental media where they are bioavailable (Baer et al. 1995). Final decisions regarding the inclusion of PAHs should be made only after site specific considerations affecting their bioavailability (e.g. size of target fragments, weathering processes, etc.) are evaluated.

- At pistol, rifle, and machine gun ranges, lead is present in the highest concentration and will be the primary COPC; however, antimony, copper, and zinc also may be COPCs. The lead alloy used for the bullet core is 99% lead and 1% antimony. All military bullets are jacketed; civilian bullets may or may not be jacketed. The jacket is 90% copper and 9.9% zinc. The highest concentrations of COPCs from bullets should be found in the target areas and primary impact berms. No COPCs from bullets, including jackets, should be found at the firing line unless there is evidence that unfired rounds have been discarded there. The brass cartridges are 70% copper and 30% zinc; however, since it is standard military practice to police the spent brass cartridges from the firing line, copper and zinc should only be COPCs at military ranges if spent cartridges have been found at the firing line, or at recreational ranges, if range management practices did not include the routine removal of cartridges.)
- While iron is found in military armor-piercing bullets, it is not a CERCLA hazardous substance, it is naturally occurring, and it has other anthropogenic sources. Although extremely high doses may be toxic to some receptors, it is seldom included as a COPC and not known to be a risk driver (relative to lead) at small arms ranges.
- Igniters are rarely found in small arms ammunition.
- Propellant components have been found at some active ranges, but not inactive ranges probably due to very short half-lives caused by weathering processes.
- Lead styphnate and lead azide are found in the primers of small arms ammunition in extremely small quantities (milligrams). They are not stable in the environment and there are no current toxicity values or analytical methods available for these species. Furthermore, analytical results for lead cannot infer the presence of either lead styphnate or lead azide. The U.S. Army Corps of Engineers has not found significant amounts of lead at firing points at closed SARs (USACE/ERDC, 2013).

**History and summary of previous investigations (if conducted)**

- Current interpretation of the distribution of COPCs.
- Summary of data gaps and sources of uncertainty.

**Potential exposure mechanisms** The CSM should address each of the following elements that affect the potential exposure and the ultimate sampling design of the investigation. The level of detail needed in the CSM included in the QAPP is driven by the phase of the investigation and the information relevant to the specific action. The graded approach should be considered and project teams should only include the elements necessary to communicate the information needed in the QAPP.

- **Element 1:** Specify the contaminant source. Summarize known/planned future uses and planned actions at the site. For example, summarize whether any soils from the site (e.g. primary impact berms) are being considered for disposal or reuse.
- **Element 2:** Identify the primary environmental fate and transport mechanisms. The form and distribution of particulate lead at a range may vary based upon the type and history of use, size and impact velocity of the round, soil characteristics (total organic carbon (TOC), particle size, pH and oxidation/reduction potential (O/RP), and past range maintenance practices. Each of these should be considered and documented in the CSM.
- **Element 3:** Identify the exposure point or area, which is the specific location(s) where receptors might come into contact with a contaminated medium. It is critically important to identify any reasonably anticipated future land use. Completion of this element should identify specific areas of the site where human activities (e.g. residential areas, children play areas) and/or sensitive habitat areas for ecological receptors (e.g. wetlands) where the potential for exposure may be higher. Consideration should also be given to the determination of appropriate receptor exposure intervals in the soil column itself.
- **Element 4:** Identify the exposure route. The exposure route is the means by which human and ecological receptors physically contact environmental contamination at the exposure point (e.g., by inhalation, ingestion, or dermal contact). For soil, exposure via incidental ingestion of small particles has historically been considered the primary route of exposure to contaminants. However, based upon the overall CSM and the anticipated future land use, the potential for acute ingestion of bulk soil or lead fragments may exist. If this exposure route is being considered, it should be clearly documented, as this will affect both the sampling design and the sample processing steps for the investigation.
- **Element 5:** Identify the potential human and ecological receptors that may come in contact with contaminants. For example: plants, waterfowl, construction workers, soil invertebrates, burrowing mammals, child residents, etc.

The following figures are examples of ways to depict CSMs.

**Figure 10- 1**

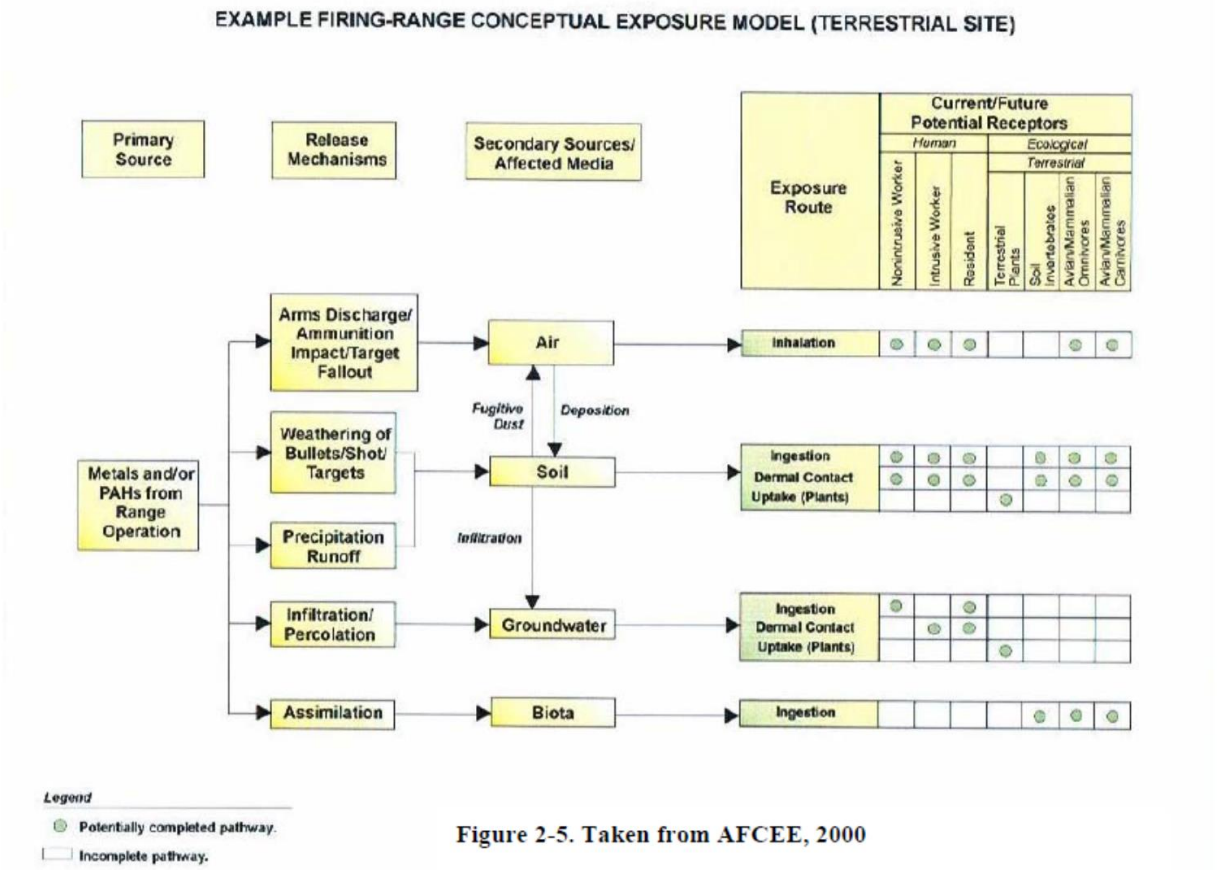
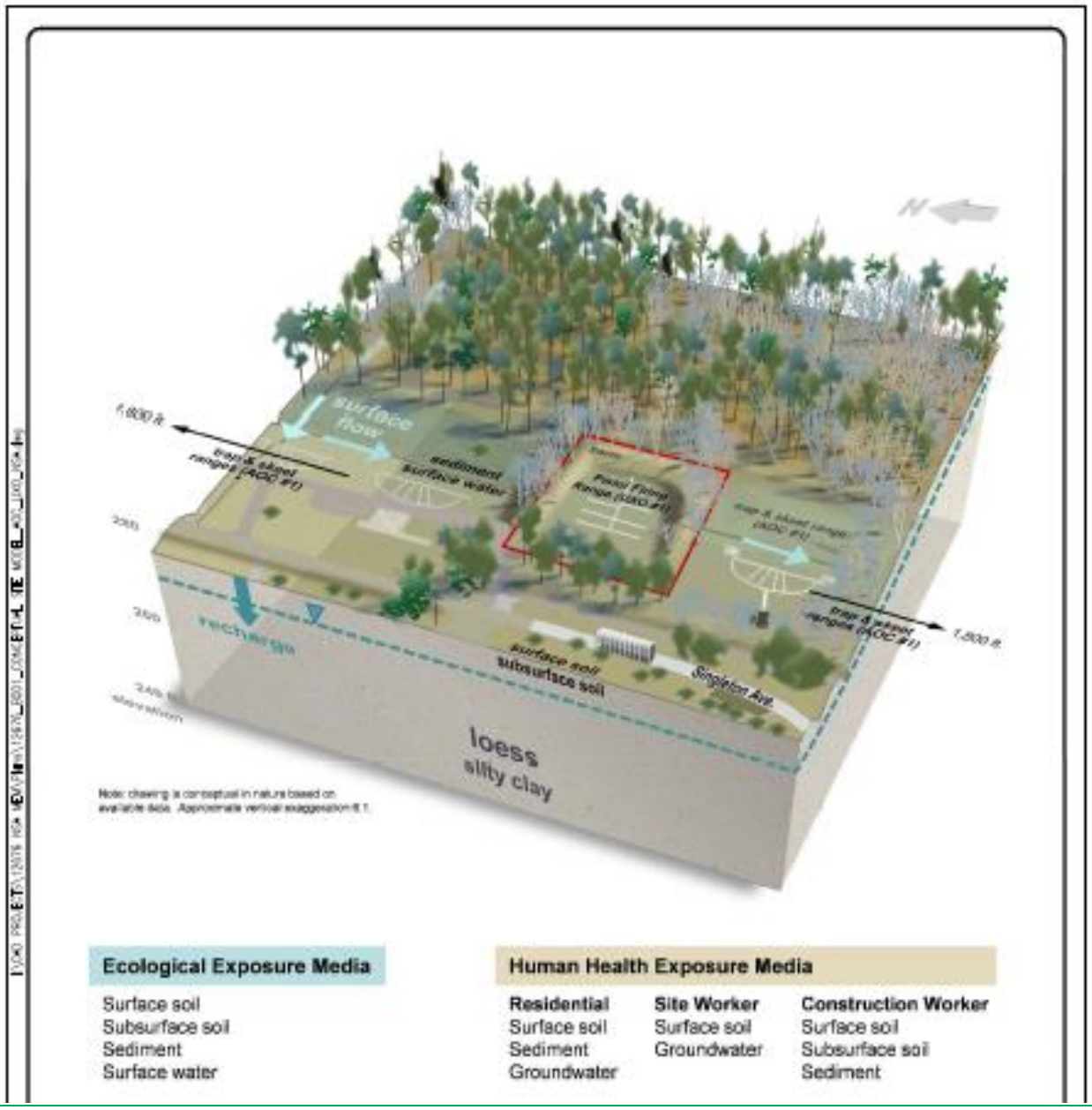



Figure 2-5. Taken from AFCEE, 2000

**Figure 10- 2**


surface flow
sediment
surface water
1,800 ft
1,800 ft
recharge
surface soil
subsurface soil
loess
silty clay
Ecological Exposure Media
Surface soil
Subsurface soil
Sediment
Surface water
Human Health Exposure Media
Residential
Surface soil
Sediment
Groundwater
Site Worker
Surface soil
Groundwater
Construction Worker
Surface soil
Subsurface soil
Sediment

# QAPP Worksheet #11: Project/Data Quality Objectives (UFP-QAPP Manual Section 2.6.1) (EPA 2106-G-05 Section 2.2.6)

This worksheet is used to develop and document data quality objectives (DQOs) using a systematic planning process (SPP). Examples of a SPP include: 1) the DQO Process (EPA 2006), and 2) the Technical Planning Process (TPP) (USACE 1998). This worksheet is mainly populated with text although inclusion of decision diagrams may be helpful. Regardless of the type of SPP applied, the QAPP must document the environmental decisions that need to be made and the level of data quality needed to ensure that those decisions are based on sound scientific data.

The following example illustrates the DQO process for a hypothetical range, using the DQO Process. Considerations are presented in green text. Examples are provided in blue text.

1. State the problem.
   [Example] Small arms munitions constituents may be present in various media at the former rifle range A, resulting from its use as a training range from 1941-1965. Sampling and analytical results from the PA/SI indicate the potential for unacceptable risks to human health and ecological receptors posed by lead in surface soils and sediments. No other COPCs were detected at concentrations exceeding risk-based screening levels in any media. The project team must characterize the lateral extent of surface soil and lead contamination sufficiently to refine estimates of risk based on the proposed future use of Range A as a recreational facility and wildlife preserve.

2. Identify the goals of the study, i.e., what are the environmental questions to be answered?
   [Example] The goals of this study are to collect data of the appropriate type, quantity and quality to determine whether there are potentially unacceptable current or future risks to human health or the environment associated with exposure to lead at Range A in surface soil and sediment.

3. Identify information inputs and uses for the information.
   [Considerations] Identify what types of data are needed, including types of samples and matrices, analytical groups, target analytes, field screening data requirements, etc., and describe how the data will be used. Depending on the stage of the investigation and range-specific DQOs, required information inputs could include the following:

- Results from visual surveys (to evaluate types and distribution of spent small arms munitions debris as well as the redistribution of debris resulting from past range management practices)
- Results from geophysical surveys (to determine the distribution of metallic debris)
- Total organic carbon, pH, cation exchange capacity (to evaluate contaminant mobility)
- Particle size analysis, prevailing wind speed and direction (to evaluate potential for air dispersion)
- Aerial photographs and personnel interviews (to identify range locations and features)
- GPS data (to map sample collection locations and decision unit boundaries).
- Rainfall data, soil type, and topography (to evaluate contaminant migration in surface water)
- Depth to groundwater and groundwater uses (to evaluate exposure mechanisms)
- Locations of nearby residential areas (to evaluate potential receptors)
- Likely penetration depth in key areas (e.g., impact berms) to establish sample depth

[Example] The concentrations of lead in surface soils and sediment will be used to estimate exposure point concentrations.
[Example] Existing background data, along with the EPA Regional Screening Levels (RSL) for Residential Soil (EPA, 2011) and the EPA Region 3 BTAG Freshwater Screening Levels (EPA 2006) will be used in the development of Project Action Levels (PALs) and documented on WS #15.

4. Define the boundaries of the study. Include or reference a map.
   Spatial Boundaries: [Considerations] Depending on the phase of the investigation, this could include the range itself, areas where stray ammunition could have been deposited, as well as any areas outside the range where potential receptors are located and potential contaminants could have been transported (e.g., surface runoff to a stream or wetland). If background data are to be collected, include the study boundaries for collecting background samples.

   Temporal Boundaries: [Example] To facilitate the collection of sediment samples, sampling will occur during late summer/early fall, when Center Creek is typically driest.

5. Develop the Analytic Approach. List the decision rules (if/then statements):
   [Example] If the average concentration of lead in each decision unit (DU)a is below the PAL or the background Upper Threshold Limit (UTL) concentration, then no further action will be recommended for that DU.
   If the average concentration of lead in any DU exceeds both the PAL and the background UTL, then a risk assessment will be conducted.
   Among other considerations, the decision to conduct further action will consider the following factors:
   - Number and magnitude of PAL exceedances across the site
   - Whether results indicate a discernible pattern of contamination

6. Specify Measurement Performance or Acceptance Criteria.
   [Example] Measurement Performance Criteria are presented in WS #12.

7. Develop the Detailed Plan for Obtaining Data.
   Describe where, when, and how the data will be collected. It is acceptable to refer to WS #17, rather than repeat that information here.

# QAPP Worksheet #17: Sampling Design and Rationale (UFP-QAPP Manual Section 3.1.1) (EPA 2106-G-05 Section 2.3.1)

This worksheet describes the sampling design and the basis for its selection. This worksheet will mainly consist of text but may include figures showing proposed sampling locations or a decision tree to guide the selection of sample locations, if this is to be done in the field. It documents Step 7 of the DQO process. If a site consists of multiple areas to be sampled, and the sampling designs and rationales are different for each area, a separate worksheet, or separate sections within this worksheet, should be used for each area.

There are two general types of sampling designs: 1) probability-based designs, which should be used when statistical conclusions are required, and 2) judgmental designs, which usually require some prior knowledge about the expected distribution of contaminants. Judgmental designs may be appropriate to help refine conceptual site models, or to confirm previous findings; however, they usually do not provide sufficient basis on their own to support statistical conclusions.

Probability-based and judgmental sample designs are not mutually exclusive, and all sample designs should make use of judgmental factors (i.e., prior knowledge based on the CSM), through "site stratification". Site stratification is the process of subdividing a study area into smaller areas (strata) having, or expected to have, similar characteristics. It is applicable to all types of sampling designs and sampling methodologies. The purpose of stratification is to differentiate and define specific, logical areas of soil (or other media) to be represented by sample results.

Dividing the site into strata optimizes the sampling design by decreasing variability and improving the representativeness of the data within each stratum, thereby maximizing the relevance of the data to project objectives and the end uses of the data. If the end use of the data is comparison to regulatory or risk-based soil screening levels, then the relevance of the strata to the risk-based exposure units should be considered in the sampling design. For example, for a rifle range, two separate strata could be delineated as areas where MC release is suspected, e.g., the impact berm and the firing line. A third stratum could be the range floor, and a fourth, the side berms.

*Regardless of the type of design selected, this worksheet should justify and explain the basis for its selection.* It also should describe the following:

- The physical boundaries for the area under study (include maps or diagrams).
- The time period (season) being represented by the collected data.
- The descriptions and basis for dividing the site into strata and sampling areas (e.g., DUs, exposure units, etc.) that support the decision statements documented on Worksheet #11.
- The basis for the number and placement of samples (or increments) within each DU.
- If sample locations are specified in the QAPP, descriptions of how actual sample positions will be located once in the field. (Include maps or diagrams).
- If a sample cannot be collected where planned, the decision process for changing the location.
- If sample locations will be determined in the field, the decision process for doing so.
- Contingencies in the event field conditions are different than expected and could have an effect on the sample design.
- Justification for the selected sampling methodology, i.e. whether composite sampling, the incremental sampling methodology (ISM), or grab (discrete) sampling will be employed.
- All sample collection and processing steps that will be employed, e.g., the number and size of each increment, the removal of debris (large projectiles, chunks of lead and metal >2mm) if performed, sieving, subsampling, and grinding. Any projectiles or metal fragments that are excluded during the sieving, if performed, should be weighed, recorded and retained. Details for these procedures should be recorded or referenced in WS 21 (field SOPs) or WS 23 (analytical SOPs), as appropriate.[2]

Although ISM has been frequently applied to the collection of samples at many ranges and other MMRP sites, its use should not be a "default" assumption. The type of sampling methodology to be employed should be selected based on careful consideration of project-

[2] It is emphasized that decisions whether to remove debris and perform sieving or grinding should be made during the development of DQOs. Historically, large bullets and/or metal fragments > 2mm in diameter are excluded from soil samples when the final results are being used to support risk assessment. For human health risk assessment, exposure to soil from incidental ingestion is assumed to be the predominant pathway, and sieving is considered to be consistent with the data quality needs relative to this exposure pathway. Ecological risk assessments also assume exposure to the smallest of soil particles as they exist in-situ; however, if acute exposure to the soil media is being considers as a viable pathway, then any bullets, fragments, or large particles that are excluded from each sample should be described in the field log and retained for further evaluation, if necessary.

specific DQOS. Depending on the DQOs, the use of ISM may or may not be appropriate. Following is a discussion of its uses and limitations:

ISM is a structured composite sampling and processing protocol designed to provide reproducible estimates of the mean concentration of analytes in a specified volume of soil (the decision unit or DU). The successful implementation of ISM consists of sample design component, a field sample collection component, and a laboratory sample processing component. ISM employs both judgmental and statistical elements.

The project team must first determine the appropriate decision unit (DU) size(s) and location(s) based on the CSM and DQOs. Determining the sizes and locations of DUs is a judgmental process. Although ISM provides excellent spatial coverage within the DU; it does not provide information on the spatial distribution of contaminants within the DU. Therefore it is critical that the project team first determine the minimum spatial concentration resolution needed in order to meet the DQO's and establish the size of DUs to reflect this resolution.

This resolution requirement (size of a DU) is site-specific and represents the smallest volume of soil about which a decision is to be made. The DU is of the appropriate size when knowledge of variability within the DU is no longer important relative to the DQOs. In most cases DUs are applied in areas that are known or thought to be fairly homogeneous or when the characterization of exposure area takes precedent over variability. Therefore, areas within a small arms range that are typically designated as separate DUs include impact berms, firing lanes, and areas with high density of shot and/or clay targets, etc. In some cases visual identification and/or the use of field screening methods such as x-ray fluorescence (XRF) can be very beneficial in identifying DUs. If information on spatial concentration variability within a DU is needed, then a smaller DU or a different sampling approach should be used.

The ISM is not appropriate for all sites. Following are some examples where the use of other types of sampling designs (e.g. judgmental) and sample collection methodologies (e.g. discrete samples) should be considered:

- There is some knowledge of the distribution of contaminants at the site and the project team has determined that judgmental sampling will better meet project-specific DQOs.
- Investigations where delineation of specific boundaries or delineation of the horizontal and vertical extent of contamination is required (judgmental sampling designs)
- Investigations where sample results from specific locations (discrete samples) are compared to regulatory limits or background concentrations.

- Acute exposure assumptions where the investigation needs to determine the maximum exposure point concentration based on exposure to a small volume of soil (discrete samples).
- For data that will be used for risk assessments, ISM sample results may not be representative of exposure point conditions as they exist *in-situ*, if grinding has been performed. This is due to the fact that grinding changes the particle size distribution of the soil, the bioavailability of contaminants, and, therefore, the true exposure point concentrations as well. In this case ISM can still be used, with the grinding step omitted.
- Applicable regulations where compositing is not permitted.

Regardless of the sampling design or sampling methodology employed, this worksheet should describe the spatial locations, sizes, and depths of all decision units and sampling points, as applicable. The spatial location, size, and depth of discrete sampling points or decision units for composite sampling should always be commensurate with the CSM and data quality objectives of the investigation. Advice on selecting appropriate sample designs may be found in Chapter 2 of *Guidance for Choosing a Sampling Design for Environmental Data Collection* (EPA 2002). For comprehensive guidance on the implementation of ISM, refer to *Incremental Sampling Methodology* (ITRC 2012).

Figures 17-1 and 17-2 are examples illustrating the stratification of a range impact berm, and the placement of samples within the strata (or decision units). Figure 17-3 illustrates the stratification of a skeet range.

**Figure 17- 1**

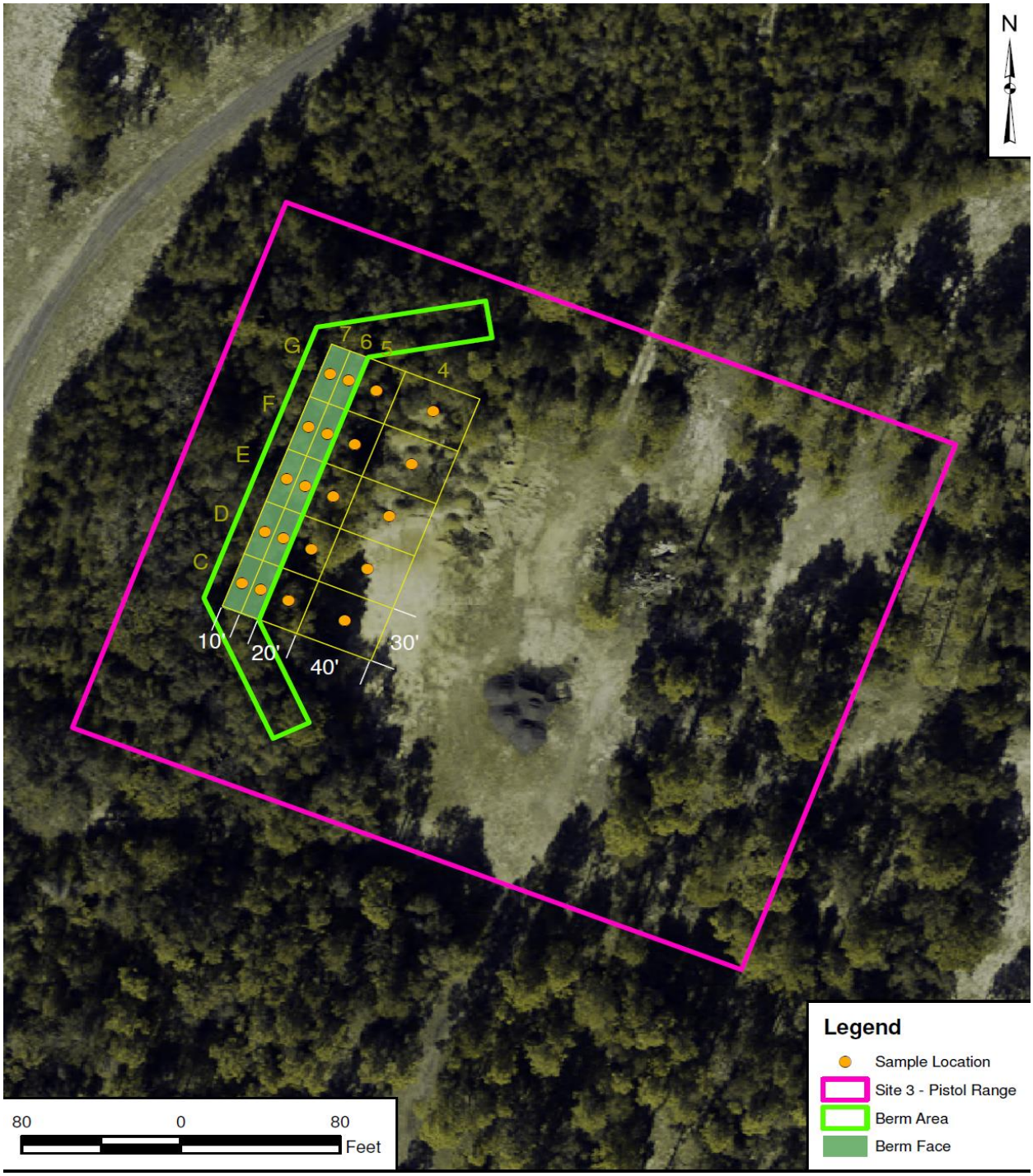
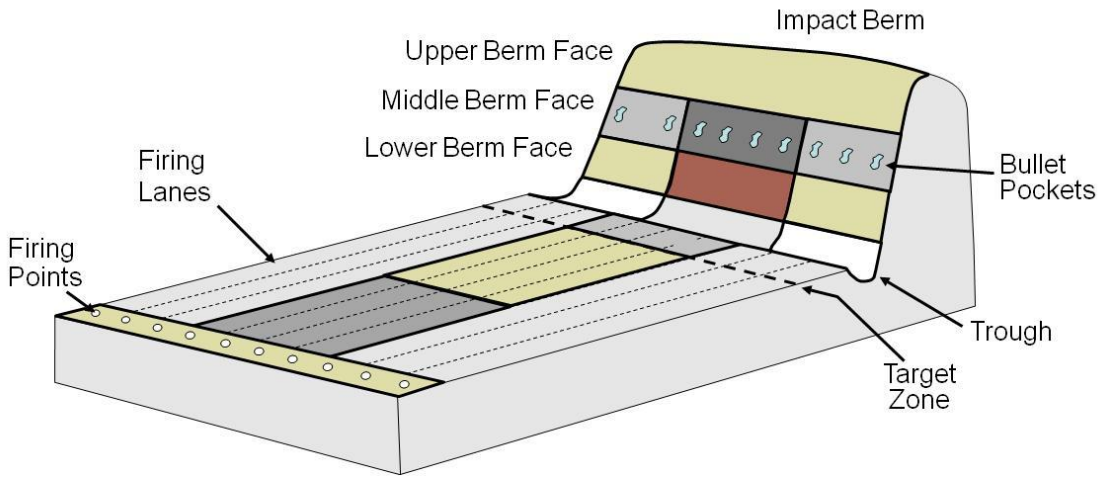
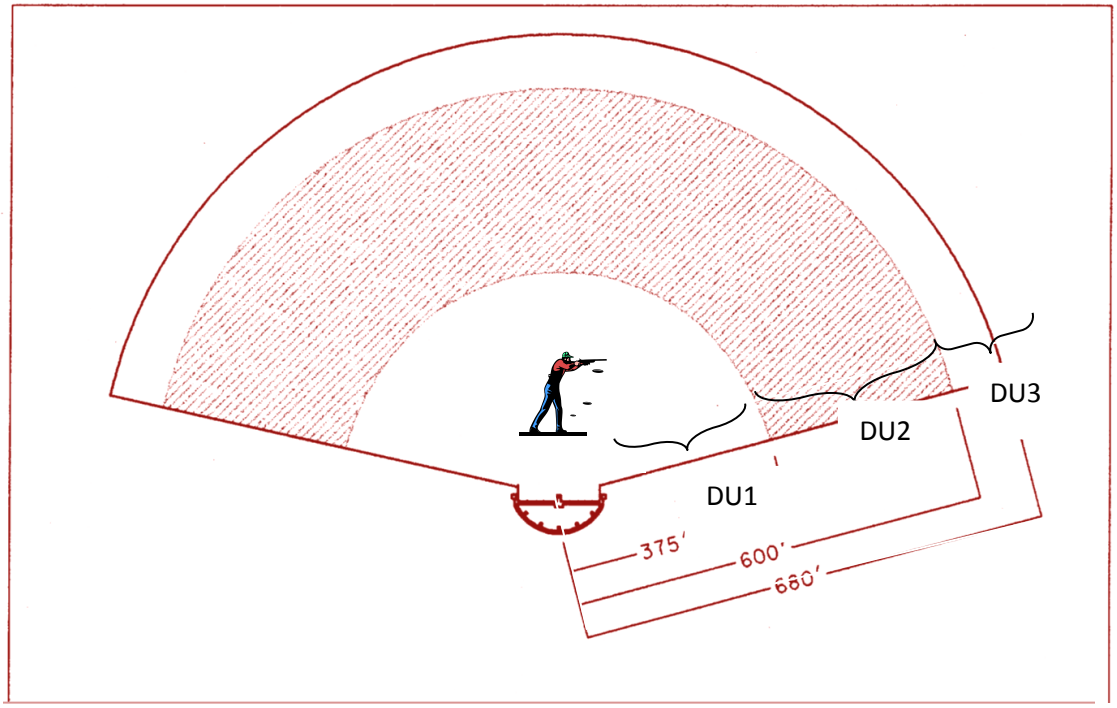

N
G
7
6
5
4
F
E
D
C
10'
20'
40'
30'
Legend
Sample Location
Site 3 - Pistol Range
Berm Area
Berm Face
80
0
80
Feet

**Figure 17- 2**




Source: Claussen, Jay L et al. 2012

**Figure 17- 3** Hypothetical shot fall zones and strata or decision units for skeet range sampling.




[Notes: The appropriate sample design for a skeet range is dependent upon several factors. The size and placement of strata or decision units should be designated based upon the density of shot location within the range. The size and shape of the shot fall zone is a function of the layout of the site, the type of shot used, and the shooting angle. In skeet shooting, the targets are thrown overhead and the shooting angle is approximately 45 degrees from the horizontal. Targets are released much closer to the ground in trap shooting; the shooting angle is approximately horizontal. Therefore, the area of highest shot density from trap shooting will tend to be less than for skeet shooting due to the angle at which shooting occurs. Another factor that affects the distance the shot will travel is the size of the shot used. When the shooting angle is approximately horizontal, the maximum distance shot will travel varies from 198 yards for No. 8 shot to 330 yards for No. 2 shot (Baldwin, 1994). Number 6 shot will cover an area between 300 and 700 feet from the shooting position when the shooting angle is level; if released from an angle of 40 degrees from the horizontal, the shot will drop between 400 and 900 feet from the shooting position. Initial screening to verify these areas can be done visually or with an XRF.]

Source: Baldwin, D. 1994.

**Table 17- 1 Shot size typically used at small arms firing ranges using shotgun rounds. Note: Shot size is generally limited to a maximum of no. 7 ½ for trap and sporting clay use, and a maximum of no. 7 ½ and minimum of no. 9 for skeet shooting.**

| Standard Sieve Size for screening | Shot size | inches | millimeter |
|---|---|---|---|
| | *Buckshot* | | |
| | No. 000-No.2 | 0.36-0.27 | 9.14-6.86 |
| | No. 3 | 0.25 | 6.35 |
| | No. 4 | 0.24 | 6.10 |
| | *Regular Shot* | | |
| | F | 0.22 | 5.59 |
| | T | 0.20 | 5.08 |
| No. 4 sieve /4 mesh (4.75 mm nominal opening) will remove BBB and larger shot | BBB | 0.19 | 4.83 |
| | BB | 0.18 | 4.57 |
| No. 5 sieve/5 mesh (4.00 mm nominal opening) will remove No.1 and larger shot | 1 | 0.16 | 4.06 |
| | 2 | 0.15 | 3.81 |
| No. 6 sieve/6 mesh (3.35 mm nominal opening) will remove No.3 and larger shot | 3 | 0.14 | 3.56 |
| | 4 | 0.13 | 3.30 |
| No. 7 sieve/7 mesh (2.80 mm nominal opening) will remove No.5 and larger shot | 5 | 0.12 | 3.05 |
| | 6 | 0.11 | 2.79 |
| | 7 | 0.10 | 2.54 |
| No. 8 sieve/8 mesh (2.36 mm nominal opening) will remove No. 7½ and larger shot | 7½ | 0.095 | 2.41 |
| | 8 | 0.09 | 2.29 |
| | 8½ | 0.085 | 2.16 |
| No.10 sieve/9 mesh (2.00 mm nominal opening) will remove all unweathered shot | 9 | 0.08 | 2.03 |

A NO. 60 MESH (0.25 MM OPENING) SIEVE IS TYPICALLY THE 'FINE ' SOIL FRACTION UTILIZED FOR INCIDENTAL HUMAN HEALTH EXPOSURE

*Source:* EPA/OSWER 2003

# QAPP Worksheet #21: Field SOPs
# (UFP-QAPP Manual Section 3.1.2)
# (EPA 2106-G-05 Section 2.3.2)

This worksheet is used to document or reference all procedures to be implemented in the field including decontaminating equipment, determining and documenting sample locations, collecting samples, and processing of samples. During the development of DQOs, the project team should reach agreement on what, if any, types of sample processing needs to occur (e.g., compositing, filtering, removal of debris, homogenization, particle size reduction, drying, sieving, subsampling etc.), and where it will be performed. Sample processing can have a significant impact on sample representativeness. Where possible, sample processing should be performed in the analytical laboratory and documented on worksheet #23. Sample processing steps performed in the field should be described in this worksheet.

If detailed field procedures are included in existing SOPs, then basic information about the SOPs should be provided in this table, and the SOPs themselves should be included in an appendix to the QAPP. Each SOP should be reviewed to ensure it reflects currently mandated practice and is either 1) sufficiently prescriptive to be implemented as written, or 2) modified as necessary for this project (which may require project-specific approval). Any planned modifications to field SOPs should be clearly noted within the SOPs included in the QAPP. If an SOP provides more than one procedure or option (for example, one SOP covers the use of several different types of field equipment for the same procedure), this worksheet should note the specific option or equipment being used. Field SOPs must be readily available to all field personnel responsible for their implementation.

| SOP # or reference | Title, Revision, Date, and URL (if available) | Originating Organization | SOP option or Equipment Type (if SOP provides different options) | Modified for Project? Y/N | Comments |
|---|---|---|---|---|---|
| DECON-003 | Decontamination SOP, Revision 3, October 2012 | | Applies to all equip. used for non-volatile organics | Y | Methanol will be used instead of acetone as the final rinse solvent. |
| SW-01A | Surface water sampling | | Water bottle sampler | Y | Samples for metals analysis will be filtered in the field. |

| | | | | | |
|---|---|---|---|---|---|
| SD-01B | Sediment sampling | | Clamshell | N | Debris will be removed, excess water will be removed, and samples will be homogenized in the field as described in SOP Option B. |
| Soil- 01A | Surface soil sampling, Revision 0, June 2012 | | Disposable trowel, Grab samples | Y | Refer to cover sheet of attached SOP for summary of deviations. |
| Soil-ISM-02A | Incremental Sampling Method for Surface Soils | | Multi-Increment Sampling Tool (MIST™) – 4.0 cm diameter | Y | 30 increments weighing approximately 50 g. each. Drying, sieving, and subsampling will be performed in the laboratory. |
| GPS-05 | Documenting sample locations with hand-held GPS | | | N | |
| XRF-06 | Use of Portable x-ray Fluorescence to locate areas with the highest concentrations of lead. | | | N | |
| HWM-01 | Collection and management of debris from hazardous waste site investigations | | | N | |
| PD-01 | Preparing photographic documentation for hazardous waste site investigations | | | N | |

# QAPP Worksheet #23: Analytical SOPs
# (UFP-QAPP Manual Section 3.2.1)
# (EPA 2106-G-05 Section 2.3.4)

This worksheet documents specific sample preparation and analytical SOPs to be used by the laboratory. All laboratory procedures must be consistent with DQOs documented on WS #11 and MPCs documented on WS #12 and WS #15. If the laboratory has not been selected at the time the QAPP is being prepared, it is acceptable to enter "TBD" for laboratory-specific information, e.g., SOP#. This worksheet must be completed, however, before the final QAPP is approved. It is recommended that copies of the laboratory SOPs be included as a hardcopy or electronic appendix to the QAPP. The project team should review all SOPs to make sure they are either 1) sufficiently prescriptive to be implemented as written or 2) modified as necessary for this project. Laboratory SOPs must meet all requirements of the DoD QSM (latest version) unless superseded by project-specific DQOs and MPCs. SOPs for any sample processing steps performed by the laboratory, including sieving, drying, grinding, and subsampling must be included or referenced. If an SOP provides more than one procedure or option (e.g., alternative extraction or cleanup procedures), the specific option being implemented must be noted. This worksheet must summarize planned modifications to existing SOPs, and modifications must be clearly noted on the copies of the SOPs that will be in use in the laboratory. Modifications may require project-specific approval relative to the specific project needs. Any approved modifications to requirements contained in the QSM, as well as potential impact to the data, should be discussed in this worksheet. Information in blue text is provided as an example only. Table 23-1 lists methods commonly used in the investigation of SARs; however other methods are acceptable. Table 23-2 provides a summary of differences between method 3050B and proposed method 3050C, designed for ISM metals in soil samples.

| SOP # | Title, Date, and URL (if available) | Definitive or Screening Data | Matrix/Analytical Group | SOP Option or Equipment Type | Modified for Project? Y/N |
|---|---|---|---|---|---|
| Prep01 | *Acid Digestion of Waters for Total Recoverable or Dissolved Metals for Analysis by FLAA or ICP Spectroscopy, 3005A, Rev 1, 01/13/13* | Definitive | Groundwater, surface water/metals | Hot block digestion | N |
| Prep02 | *Acid Digestion of Sediments, Sludges, and Soils, 3050B, Rev 1.5, 01/13/13* | Definitive | Soil, sediment/metals | Hot Block digestion | N |
| Met01 | *Metals by ICP-MS – 6020A* | Definitive | GW, SW, Soil, Sed/metals | ICP-MS | N |
| Prep03 | *Preparation of soil samples collected using modified method 3050* | Definitive | Soil/metals, PAHs | Grinding performed in the laboratory | Y |

**Table 23- 1 Methods commonly used in the investigation of small arms ranges**

| Potential Constituent(s) of Concern | Matrix | Preparation/Extraction Method[3] | Analytical Method(s) | Notes |
|---|---|---|---|---|
| Metals [The list of target analytes should be based on project DQOs.] | groundwater, surface water | SW-846 3005A: Acid digestion of Waters for Total Recoverable or Dissolved Metals for Analysis by FLAA or ICP Spectroscopy<br>SW846 3015A: Microwave Assisted Digestion of Aqueous Samples and Extracts | SW-846 6010C: Inductively Coupled Plasma-Atomic Emission Spectrometry (ICP-AES)<br>SW-846 6020A: Inductively Coupled Plasma-Mass Spectrometry (ICP-MS) | Both preparation methods are applicable to both analytical methods.<br>Metals may also be analyzed by FLAA or GFAA, however those techniques are not commonly used anymore, as ICP-AES and ICP-MS are more sensitive.<br>ICP-MS generally has the lowest |

[3] Sample preparation procedures are highly dependent upon the objectives of the project and influenced by variables such as exposure assumptions, receptors, and assumed future land use. If the sample design utilizes incremental sampling, the grinding procedures in method 8330B may not be appropriate for metals.

| Potential Constituent(s) of Concern | Matrix | Preparation/Extraction Method[3] | Analytical Method(s) | Notes |
|---|---|---|---|---|
| | | | | detection limits. |
| Metals [The list of target analytes should be based on project DQOs.] | soil, sediment | SW-846 3050C modified: Acid Digestion of Sediments, Sludges, and Soils<br>SW-846 3051A: Microwave Assisted Digestion of Sediments, Sludges, Soil, and Oils<br>ITRC 2012: Laboratory processing (drying, sieving, grinding & subsampling) for use with samples collected using ISM. | SW-846 6010C: Inductively Coupled Plasma-Atomic Emission Spectrometry (ICP-AES)<br>SW-846 6020A: Inductively Coupled Plasma-Mass Spectrometry (ICP-MS) | Both preparation methods are applicable to both analytical methods.<br>Metals may also be analyzed by FLAA or GFAA, however those techniques are not commonly used anymore, as ICP-AES and ICP-MS are more sensitive.<br>ICP-MS generally has the lowest detection limits. |
| PAHs | surface water | SW-846 3510C: Separatory Funnel Liquid-Liquid Extraction<br>SW-846 3520C: Continuous Liquid-Liquid Extraction<br>SW-846 3535A: Solid-Phase Extraction | SW-846 8310: Polynuclear Aromatic Hydrocarbons by High Performance Liquid Chromatography (HPLC)<br>SW-846 8270D SIM: Semivolatile Organic Compounds by Gas Chromatography/Mass Spectrometer (GCMS) Selected Ion Monitoring (SIM) | PAHs may also be analyzed by Gas Chromatography (GC) (Method 8100), however, this technique is not commonly used anymore, as HPLC and GC/MS SIM can achieve lower detection limits. |
| PAHs | soil, sediment | SW-846 3540C: Soxhlet Extraction<br>SW-846 3541: Automated Soxhlet Extraction<br>SW-846 3550C: Ultrasonic Extraction<br>SW-846 3561: Supercritical Fluid Extraction of Polynuclear Aromatic Hydrocarbons | SW-846 8310: Polynuclear Aromatic Hydrocarbons by High Performance Liquid Chromatography (HPLC)<br>SW-846 8270D SIM: Semivolatile Organic Compounds by Gas Chromatography/Mass Spectrometer (GCMS) Selected Ion Monitoring (SIM) | PAHs may also be analyzed by Gas Chromatography (GC) (Method 8100), however, this technique is not commonly used anymore, as HPLC and GC/MS SIM can achieve lower detection limits. |

**Table 23- 2: Salient Differences between Method 3050B and Proposed Method 3050C[4]**

| Process | Method 3050B/ Conventional Sampling | Proposed Method 3050C/ Incremental Sampling Methodology |
|---|---|---|
| Field sampling | Not explicitly addressed in method. Typically, grab/discrete samples are collected. | An incremental sample consists of 30 -100 "increments" collected randomly over the entire DU (e.g., using systematic sampling). For cohesive surface soils, an "increment" typically consists of a small cylindrical soil core (e.g., 2-5 cm in length) collected with a 2-4 cm diameter coring device. |
| Sample mass and containers | Approximately 200 g of soil in 4-oz wide-mouth amber glass jars with screw-top lids. | Typically, 1-2 kg of soil in clean large (e.g., 15 ×15 inches, 6 mm thick) polyethylene plastic bags sealed with Ty-wraps. |
| Sample drying | Sample drying is optional and not typically done. | Sample is air-dried at room temperature by spreading onto a tray to form a thin uniform slab. |
| Sieving | "…sieve, if appropriate and necessary, using a USS #10 sieve…" Soil samples are typically not sieved. | Samples are passed through a #10 (2-mm) sieve. Both size fractions are weighed and < 2 mm fraction is additionally processed. |
| Milling | "Wet samples may be dried, crushed, and ground to reduce sample variability…" Milling is typically not performed. | Samples are milled using appropriate mechanical grinders such as puck or roller (ball) mills. Milling must result in finely ground material of uniform appearance and texture. Recommend 5 x 60 sec w/ 1min cooling period for the puck mill when metals and energetics are desired. For metals only, a cooling period is not needed. Recommend 8 hrs. for ball mill for metals only. |
| Laboratory sub-sampling | "Mix the sample thoroughly to achieve homogeneity…" Soil is often stirred with a spatula or similar device (often in original container) and a single aliquot (e.g., scooped from the top of the container) collected as the sub-sample for digestion and analyses. | After milling, the soil is spread onto a large tray to form a thin slab of material of uniform thickness. At least 20 small aliquots are randomly collected over the entire slab with a flat-edged spatula with sides or similar device and combined to prepare a sub-sample for digestion and analysis. |
| Sub-sample mass | 0.5-2 g wet weight or 1 g dry weight | 2-10 g dry weight |

[4] Source: USACE/ERDC 2012

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